# A Role for AVIRIS in the Landsat and Advanced Land Remote Sensing System Program

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## ABSTRACT

As a calibrated imaging spectrometer flying at a 20 km altitude, AVIRIS may contribute to the Landsat and the Advanced Land Remote Sensing System efforts. These contributions come in the areas of: 1) on-orbit calibration, 2) specification of new spectral bands, 3) validation of algorithms and 4) investigation of an imaging spectrometer for the Advanced Land Remote Sensing System.

## 1.0 INTRODUCTION

AVIRIS is a NASA-sponsored Earth-looking imaging spectrometer that measures the total upwelling radiance from 400 to 2500 nm through 224 imaging channels. A plot showing the 224 channels of AVIRIS and the six bands of the Landsat Thematic Mapper is shown in Figure 1. For AVIRIS, typically up to 10 images of 11 by up to 100 km at 20 m spatial resolution are acquired on a single flight. AVIRIS data are rigorously calibrated in the laboratory (Chrien et al., 1990) and validated inflight with respect to their spectral and radiometric characteristics. These characteristics are summarized in Table 1.

Currently Landsat has 6 bands in the 400 to 2500 nm spectral region. There is an increasing requirement that Landsat data be well calibrated to fulfill the measurement and monitoring roles of the Landsat data. Under the Advanced Land Remote Sensing System (ALRSS) there are options to add to the spectral coverage of sensors beyond Landsat 7. In this paper we describe potential contributions by AVIRIS in the areas of calibration and measurement augmentation to Landsat and ALRSS program.

## 2.0 RADIOMETRIC AND SPECTRAL CALIBRATION

Valid radiometric calibration is essential for many of the current and proposed algorithms and monitoring activities of Landsat. Because AVIRIS is a calibrated imaging spectrometer operating at 20 km altitude, underflights of Landsat by AVIRIS may be used to validate and/or establish the on orbit spectral and radiometric characteristics.

Spectral calibration algorithms are being developed to use concurrently acquired AVIRIS and Landsat-type data. These algorithms use a concurrently acquired AVIRIS and spaceborne sensor data to solve directly for the spectral band shapes. Concurrently acquired data over spectrally varying surface and atmospheric targets are required. From these data, a least squared error fitting algorithm is used to calculate the spectral band shape of the spaceborne sensor.

The radiometric calibration of Landsat may be established through underflight of Landsat by AVIRIS. Because AVIRIS is calibrated inflight (Green et al., 1993a) and AVIRIS measures data at a 20 km altitude, a Landsat calibration may occur in a nonclear sky or even cloudy conditions. This is a significant operational advantage over ground based calibrations.

AVIRIS is currently being used in this mode to calibrate the Optical Sensor (OPS) on board the Japanese Environmental Satellite JERS-1 (Green et al., 1993b). A plot showing the accurate convolution of the AVIRIS channels to the JERS-1 OPS bands is given in Figure 2. In Figure 3 the upwelling OPS radiance derived from AVIRIS is given. In the Landsat program, AVIRIS could be used in this mode beginning with Landsat 6.

## 3.0 SPECIFICATION OF FUTURE ALRSS BANDS

Analysis of AVIRIS data sets may be used to specify future bands for measuring and monitoring the Earth's surface as well as collecting information for the atmospheric correction of ALRSS data. Based on research with AVIRIS data there is evidence that additional spectral bands would improve measurements of: soils and rocks; manmade objects; vegetation; snow and ice; as well as coastal and inland waters.

In addition, based on analysis of AVIRIS data sets, ALRSS bands might be specified to measure: water vapor, aerosols, surface pressure, cirrus clouds, etc. for atmospheric correction (Green et al., 1993c; Goetz et al., 1993).

AVIRIS data may be used to investigate the optimal spatial resolution of ALRSS bands. For example, bands devoted to atmospheric characterization may not require the same high spatial resolution required for the measurement of surface features.

## 4.0 TESTING AND VALIDATION OF ALGORITHMS

Once a set of bands have been designated for the ALRSS sensor, AVIRIS data may be acquired and spectrally convolved to the exact band shapes. These simulated ALRSS images may be used to test proposed algorithms for the surface and atmosphere under a range of conditions. With this preparation, validated algorithms will be in place in advance of the spaceborne sensor launch.

## 5.0 AN IMAGING SPECTROMETER ON BOARD THE ALRSS

AVIRIS data are currently used for investigations spanning the disciplines of: terrestrial ecology; geology and soils oceanography and limnology; hydrology; atmospheric gas and aerosol investigations; snow hydrology; general spectral signature detection and evaluation; calibration; and algorithm development. It has been proposed to support these investigations and applications globally that an imaging spectrometer be included on an ALRSS. AVIRIS data may be used to evaluate requirements and tradeoffs between the spectral and spatial coverage for such a sensor on the ALRSS.

## 6.0 CONCLUSION

AVIRIS currently measures data for NASA investigators from the 20 km altitude of the ER-2 aircraft platform. Work is ongoing to maintain and improve the performance characteristics of the AVIRIS sensor. The current spectral, radiometric, geometric and calibration characteristics of AVIRIS allow it to fulfill an important role in the calibration of Landsat sensors. In addition, AVIRIS may be used to specify new bands and new capabilities on the ALRSS.

## 7.0 ACKNOWLEDGMENTS

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## 8.0 REFERENCES

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**9.0 TABLE**

Table 1. AVIRIS Data Characteristics

| | |
|---|---|
| <u>SPECTRAL</u> | |
| Wavelength range | 400 to 2500 nm |
| Sampling | < 10 nm |
| Spectral response (fwhm) | 10 nm nominal |
| Calibration | <= 1 nm |
| <u>RADIOMETRIC</u> | |
| Radiometric range | 0 to maximum lambertian |
| Sampling | ~1 dn noise rms |
| Absolute calibration | <= 7 % |
| Intraflight calibration | <= 2 % |
| Precision/noise | exceeding NEdL/SNR requirement |
| <u>GEOMETRIC</u> | |
| Field of view (FOV) | 30 degrees |
| Instantaneous FOV | 1.0 mrad |
| Calibration | <= 0.2 mrad |
| Flight line length | Up to ten 100 km flight lines |

10.0 FIGURES

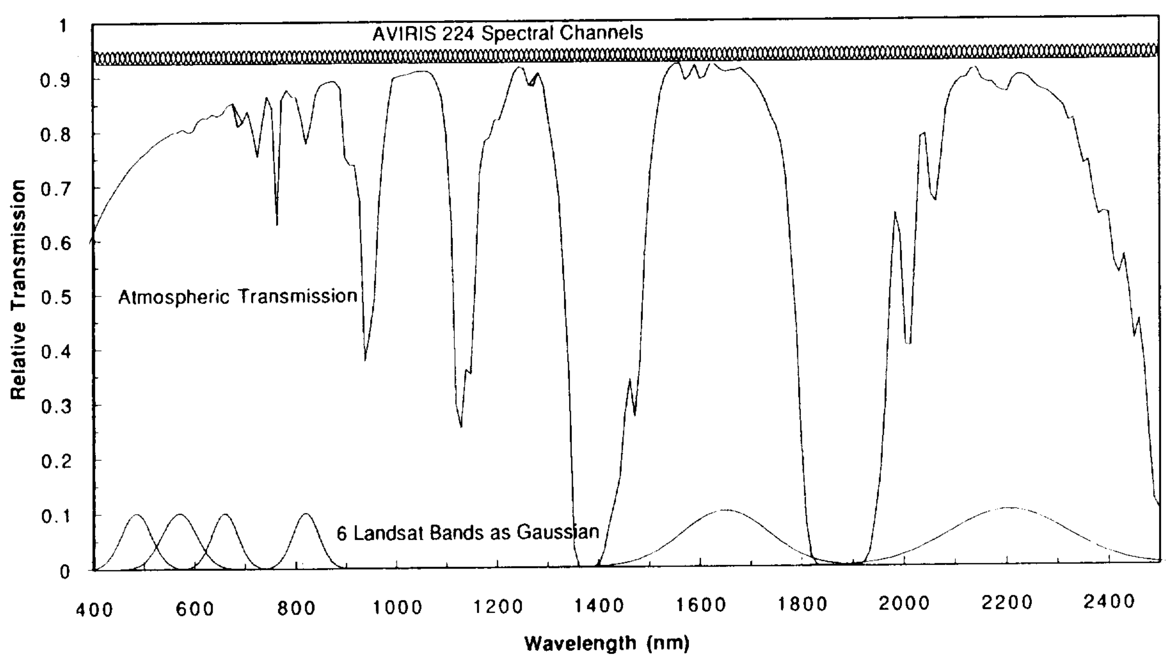


Figure 1. 224 AVIRIS channel plotted with the 6 visible to short wavelength infrared bands of the Landsat Thematic Mapper modeled as gaussian functions. A terrestrial transmission spectrum is shown as well.

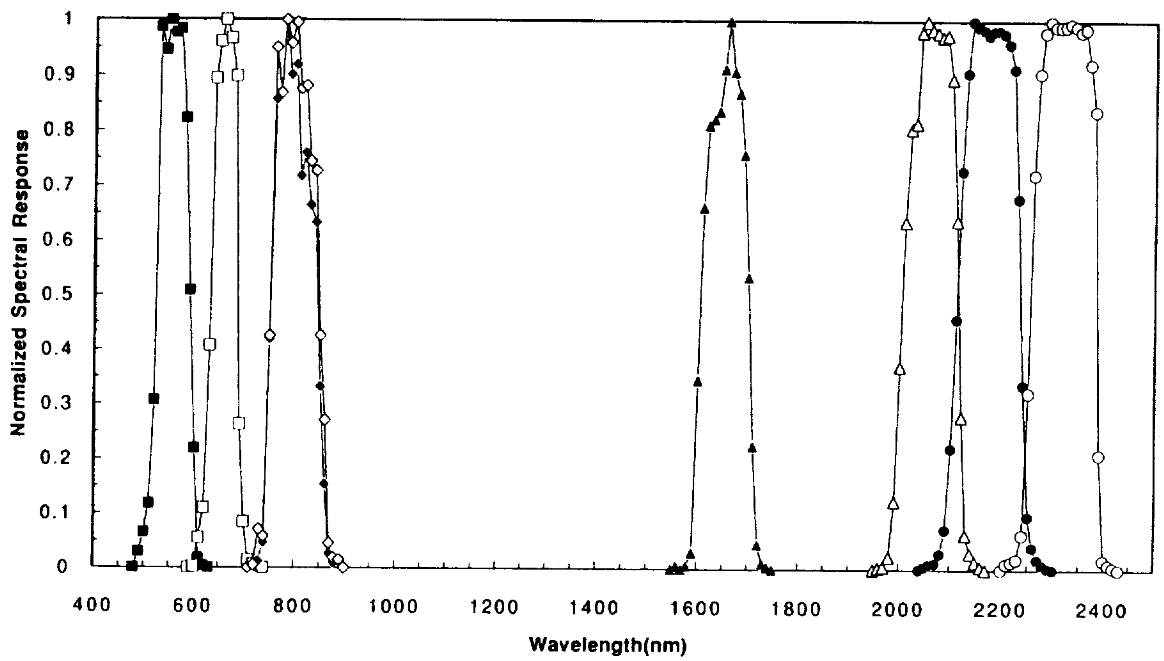


Figure 2. Weighted convolution filters mapping AVIRIS spectral channels to JERS-1 OPS bands.

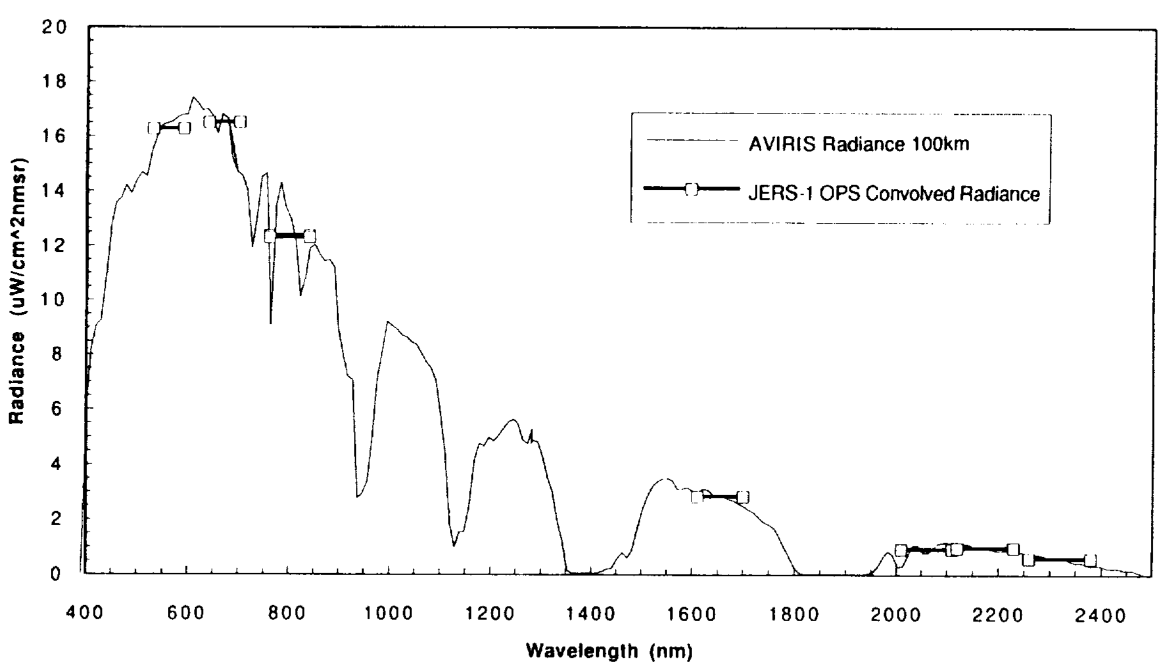


Figure 3. Measured upwelling radiance convolved to the JERS-1 OPS bands and AVIRIS radiance spectrum.